Amendments to the Claims

Please amend Claims 31, 32, 56, 60, and 61. The Claim Listing below will replace all prior versions of the claims in the application:

Claim Listing

1-30. (Canceled)

31. (Currently amended) A method for forming a semi-solid metal alloy, comprising:

a. superheating a metal alloy above the liquidus temperature of the metal alloy;

b. directing the superheated metal alloy into a nucleation reactor having a plurality of intersecting inner channels such that the metal alloy is directed into at least two intersecting inner channels;

c. passively mixing the superheated metal alloy via fluid impingement and convection within the nucleation reactor;

d. cooling the superheated alloy within the nucleation reactor to a temperature between a solidus temperature and a liquidus temperature of the alloy to form a plurality of nuclei, thereby producing a nucleated alloy; and

e. passively mixing the nucleated alloy, via fluid impingement and convection in the nucleation reactor, at a temperature between the solidus temperature and the liquidus temperature of the alloy, without raising the temperature of the alloy to thereby prevent the nuclei from melting, thereby forming the semi-solid metal alloy.

32. (Currently amended) The method of Claim 31 wherein the nucleation reactor includes a first melt inlet, a second melt inlet, a first inner channel in fluid communication with the first melt inlet, and a second inner channel in fluid communication with the second melt inlet; wherein the first inner channel and the second inner channel intersect at a first junction and ~~steams~~ streams of the same superheated alloy flowing ~~into~~ from the first

inner channel and the second inner channel passively mix via fluid impingement and convection.

33. (Previously presented) The method of Claim 32 wherein the nucleation reactor further includes a third inner channel and a fourth inner channel that also intersect at the first junction and wherein the alloy separates into streams flowing into the third inner channel and the fourth inner channel.

34. (Previously presented) The method of Claim 33 wherein the third inner channel and the fourth inner channel intersect at a second junction downstream from the first junction and wherein streams of alloy flowing through the third inner channel and the fourth inner channel passively mix via fluid impingement and convection.

35. (Previously presented) The method of Claim 31 further comprising cooling the semi-solid metal alloy to a temperature below a solidus temperature of the semi-solid metal alloy.

36. (Previously presented) The method of Claim 31 wherein the superheated alloy is cooled at a rate of at least 15°C per second to form the nucleated alloy.

37. (Previously presented) The method of Claim 36 wherein the superheated alloy is cooled at a rate in the range of about 20°C per second to about 30°C per second to form the nucleated alloy.

38. (Previously presented) The method of Claim 31 wherein the superheated alloy includes at least one of the materials selected from the group consisting of aluminum, lead, tin, magnesium, manganese, strontium, titanium, silicon, iron, carbon, copper, gold, silver, and zinc.

39. (Previously presented) The method of Claim 31 further including the step of using the semi-solid metal alloy in at least one application selected from the group consisting of thixocasting applications and rheocasting applications.

40. (Previously presented) The method of Claim 31 wherein the semi-solid metal alloy is substantially free of dendrites.

41. (Previously presented) The method of Claim 31 wherein the semi-solid metal alloy includes a primary particle size of about 100 microns or less.

42. (Previously presented) The method of Claim 41 wherein the semi-solid metal alloy includes a primary particle size of about 70 microns or less.

43. (Previously presented) The method of Claim 31 wherein the semi-solid metal alloy includes a shape factor value in the range of about 0.75 and about 0.95.

44. (Previously presented) The method of Claim 31 further including the step of molding the semi-solid metal alloy in a metal-forming process.

45. (Previously presented) The method of Claim 31 wherein the superheated alloy includes at least one grain-refining agent.

46. (Previously presented) The method of Claim 45 wherein the grain-refining agent includes at least one of the materials selected from the group consisting of borides of titanium and borides of aluminum.

47. (Previously presented) The method of Claim 45 wherein the grain-refining agent includes at least one of the materials selected from the group consisting of TiB_2, AlB_2, TiC, and Al_3Ti.

48. (Previously presented) The method of Claim 31 wherein the superheated alloy is cooled from a temperature at least about 5°C above the liquidus temperature.

49. (Previously presented) The method of Claim 48 wherein the superheated alloy is cooled from a temperature in the range of between about 10°C to about 15°C above the liquidus temperature.

50. (Previously presented) The method of Claim 31 further including the step of forming a billet from the semi-solid metal alloy.

51. (Previously presented) The method of Claim 31 wherein at least a portion of the superheated alloy includes a metal or alloy recycled from a metal-forming process.

52. (Previously presented) The method of Claim 31 further including the step of directing the semi-solid metal alloy to a metal-forming process.

53. (Previously presented) The method of Claim 52 wherein the semi-solid metal alloy directed to a metal-forming process includes a volume fraction of solids of at least about 30%.

54. (Previously presented) The method of Claim 53 wherein the semi-solid metal alloy directed to a metal-forming process includes a volume fraction of solids in the range of from about 40% to about 60%.

55. (Previously presented) A semi-solid metal alloy formed by the process of Claim 31.

56. (Currently amended) A method for forming a semi-solid metal alloy, comprising:

a. superheating a metal alloy above the liquidus temperature of the metal alloy;

b. directing the superheated metal alloy into a nucleation reactor which includes:

i. a first melt inlet and a second melt inlet;

ii. a first inner channel in fluid communication with the first melt inlet and a second inner channel in fluid communication with the second melt inlet;

wherein the first inner channel and the second inner channel intersect at a first junction and wherein ~~steams~~ streams of the alloy flowing through the first inner channel and the second inner channel passively mix via fluid impingement and convection; and

iii. a third inner channel and a fourth inner channel;

wherein the third inner channel and a fourth inner channel also intersect at the first junction and wherein the alloy separates into streams flowing into the third inner channel and the fourth inner channel and wherein the third inner channel and the fourth inner channel intersect at a second junction downstream from the first junction and wherein streams of alloy flowing through the third inner channel and the fourth inner channel passively mix via fluid impingement and convection;

wherein the superheated metal alloy is directed into both the first melt inlet and the second melt inlet of the nucleation reactor; and

c. cooling the superheated alloy within the nucleation reactor to a temperature between a solidus temperature and a liquidus temperature of the alloy to form a plurality of nuclei and controlling the temperature of the alloy to prevent a substantial number of the nuclei from melting, thereby forming the semi-solid metal alloy.

57. (Previously presented) The method of Claim 56 further comprising cooling the semi-solid metal alloy to a temperature below a solidus temperature of the metal alloy.

58. (Previously presented) The method of Claim 56 wherein the first inner channel and the second inner channel intersect at the first junction at an angle of about 90°.

59. (Previously presented) The method of Claim 56 wherein the third inner channel and the fourth inner channel intersect at the second junction at an angle of about 90°.

60. (Currently amended) A method for forming an semi-solid metal alloy, comprising:

~~a. superheating a first metal, or alloy thereof, above the liquidus temperature of the first metal or alloy thereof;~~

~~b. superheating a second metal, or alloy thereof, above the liquidus temperature of the second metal or alloy thereof;~~

~~c. directing the superheated first metal and the superheated second metal, or alloys thereof, into a nucleation reactor, the nucleation reaction having a plurality of intersecting inner channels;~~

~~d. passively mixing the first and second metals, or alloys thereof, via fluid impingement and convection within the nucleation reactor, thereby forming an intermediate alloy;~~

~~e. cooling the intermediate alloy within the nucleation reactor to a temperature between a solidus temperature and a liquidus temperature of the alloy to thereby form a plurality of nuclei, thereby forming a nucleated alloy; and~~

~~f. passively mixing the nucleated alloy, via fluid impingement and convection within the nucleation reactor, at a temperature between the solidus temperature and the liquidus temperature of the nucleated alloy, without raising the temperature of the alloy stream to thereby prevent the nuclei from melting, thereby forming the semi-solid metal alloy.~~

a. directing a metal alloy, heated above the liquidus temperature of the metal alloy, into a nucleation reactor, the nucleation reactor having a plurality of intersecting inner channels such that the metal alloy is streamed into at least two intersecting inner channels;

b. impinging streams of the metal alloy directed into the at least two intersecting inner channels at an intersection thereof;

c. cooling the metal alloy within the nucleation reactor to a temperature between a solidus temperature and a liquidus temperature of the metal alloy to thereby form a plurality of nuclei, thereby forming a nucleated alloy; and

d. passively mixing the nucleated alloy at a temperature between the solidus temperature and the liquidus temperature of the nucleated alloy, without raising the temperature of the alloy stream to thereby prevent the nuclei from melting, thereby forming the semi-solid metal alloy.

61. (Currently amended) The method of Claim 60 wherein the nucleation reactor includes:

a. a first melt inlet and a second melt inlet;

b. a first inner channel in fluid communication with the first melt inlet and a second inner channel in fluid communication with the second melt inlet;

wherein the first inner channel and the second inner channel intersect at a first junction and wherein a first stream of the ~~first metal, or~~ alloy ~~thereof,~~ flowing through the first inner channel and a second stream of the same ~~second metal, or~~ alloy ~~thereof,~~ flowing through the second inner channel passively mix via fluid impingement and convection; and

c. a third inner channel and a fourth inner channel;

wherein the third inner channel and a fourth inner channel also intersect at the first junction and wherein the alloy separates into streams flowing into the third inner channel and the fourth inner channel and wherein the third inner channel and the fourth inner channel intersect at a second junction downstream from the first junction and wherein streams of alloy flowing through the third inner channel and the fourth inner channel passively mix via fluid impingement and convection.

62. (Previously presented) The method of Claim 61 wherein the first inner channel and the second inner channel intersect at the first junction at an angle of about 90°.

63. (Previously presented) The method of Claim 61 wherein the third inner channel and the fourth inner channel intersect at the second junction at an angle of about 90°.

64. (Previously presented) The method of Claim 60 further comprising cooling the semi-solid metal alloy to a temperature below a solidus temperature of the metal alloy.

65. (Previously presented) A semi-solid metal alloy formed by the process of Claim 60.